Original Article

A cone-beam computed tomographic analysis of total dentin removed, canal transportation, and canal-centering ability following instrumentation with three different file systems: An *in vitro* study

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Abstract

Aims: The aim of this study was to evaluate the shaping ability following instrumentation with XP-endo Shaper (XPS), TruNatomy (TRN), and HyFlex CM (HCM) file system.

Subjects and Methods: Fifty-four mesiobuccal canals of mandibular molars were selected and allocated into three groups randomly: XPS, TRN system, and HCM file system. Pre- and postinstrumentation scans were taken using a cone-beam computed tomography scanner to determine the amount of root dentin removed, mesiodistal and buccolingual transportation, and canal-centering ratio at 2, 5, and 8 mm from the root end.

Statistical Analysis Used: Data were statistically analyzed using Kruskal–Wallis test and the significance level was set at $P = 0.05$.

Results: TRN file system removed the least amount of root dentin. XPS showed statistically higher M-D canal transportation at 5 mm level from the apex.

Conclusions: TRN file system showed better dentin preservation as compared to XPS and HCM. XPS showed the highest canal transportation at 5 mm. All three file systems performed similarly in terms of canal-centering ability.

Keywords: Hyflex CM; TruNatomy; XP-endo Shaper

INTRODUCTION

Dental clinicians now have exposure to advanced nickel-titanium (NiTi) rotary files with higher flexibility and greater resistance to cyclic fatigue as a result of changing canal preparation protocols during the last few decades.[1]

NiTi instruments produce well-tapered root preparations by preserving the root canal anatomy and the portion of the apical foramen intact.[2] Advances in NiTi technology have led to improvement in curved canal preparation, reduction of anatomic deformities, and lowered risk of instrumentation accidents.[3] However, excessive dentin removal during instrumentation with greater taper NiTi rotary instruments is a well-known risk factor that can result in root fractures.[4] Zandbiglari *et al*.[5] investigated how taper affected the resilience of endodontically treated teeth to fracture and discovered that roots that were prepared with greater taper instruments were significantly less resilient. As a result, a system that overcomes this limitation and thus conserves dentin, decreases canal transportation, and displays better centering ability is required.

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XP-endo Shaper (XPS) (FKG Dentaire, La Chaux-de-Fonds, Switzerland) is a single rotary file system manufactured from Max wire alloy with a booster tip, a triangular cross-section, and a feature that permits contraction and expansion of file during movement, beginning at ISO 15/0.01 and progressively increasing the working field up to 30/0.04.[6] TruNatomy (TRN) (Dentsply Sirona, Ballaigues, Switzerland) rotary instruments have an off-centered parallelogram cross-section, a regressive taper, a smaller initial wire blank of 0.8-mm diameter and are subjected to thermal treatment postmanufacture.[7] HyFlex CM (HCM) (Coltene, Altstätten, Switzerland) rotary files have 300% greater separation resistance. These files are created using a specialized process that controls the material's memory, resulting in extremely flexible files. It reverts to its original shape after sterilization and can thus be used multiple times.[8]

A detailed search of literature revealed a paucity of studies that evaluated the shaping abilities of XPS, TRN, and HCM files. Hence, this study aimed at comparing the amount of dentin removed, canal transportation, and centering ability of XPS, TRN, and HCM file systems using cone-beam computed tomographic (CBCT) analysis.

SUBJECTS AND METHODS

Sample selection

The study was evaluated and accepted by the Institutional Ethics Committee (Review No: GDCH/IEC/VII-2022(10)-PROV).

For the current *in vitro* study, 54 extracted mandibular molar teeth were collected. Teeth with fully formed root apices and having mesiobuccal canal curvature of 20°–35° according to Schneider's method[9] were included in the study. Exclusion criteria included teeth with calcified canals, immature open root apices, apical root resorption, and variations in canal anatomy. The teeth were decoronated 13 mm from the apex. After sectioning the roots at the furcation level, the distal roots were discarded. Disinfection of teeth was carried out with 10% formalin solution (Cepham Life Sciences, USA) and stored in a sterile saline solution. Mesiobuccal canals were located with DG 16 explorer (Hu-Friedy Mfg. Co., Chicago, USA) following access cavity preparation with Endo Access Bur (Dentsply Maillefer, USA). The patency of the root canals was then checked with the number 10 K-file (Mani Inc., Tochigi Ken, Japan).

Initial scanning

After initial instrumentation, the teeth were embedded in silicone material (Zetaplus condensation silicone, Zhermack, Badia Polesine, Italy) in a custom-made box. Adhesive tape was placed over the apical foramina to create a seal in the apical area. For standardization, scanning of each specimen was carried out with a ProMax CBCT unit (Planmeca, Helsinki, Finland) in special endo mode (5 cm × 5.7 cm field of view, 90 kVp, 4 mA, 15 s exposure time, 75 μm voxel size). Using the software's scale, six axial slices of 2, 5, and 8 mm were detected and measured.

Root canal preparation

In Group 1, XPS was used to prepare the mesiobuccal canals using a TriAuto mini endomotor (J MORITA, Tokyo, Japan) with pecking motions at 3–4 mm amplitude up to working length and 800 rpm and 1 Ncm torque.

In Group 2, the TRN file system was slowly moved in and out until it reached the working length at 500 rpm speed and 1.5 Ncm torque. The sequence used was orifice modifier (20/0.08), TRN Glider (17/0.02), and then followed by TRN Prime shaping file (26/0.04) up to the working length.

In Group 3, a glide path was created using no.20K file, followed by instrumentation with 15/04, 20/04, 25/04 HCM files at 2.5 Ncm torque, and 500 rpm speed up to working length.

A 30-gauge NaviTip side-vented needle (Ultradent Inc., South Jordan, Utah, USA) attached to a disposable syringe was used to perform extensive irrigation with 5 mL 3% NaOCl solution after each instrument. The canals were then rinsed with saline solution after being flushed for 1 min with 1 mL of 17% ethylenediaminetetraacetic acid. All the root canal preparations were carried out by a single operator.

Final scanning

Final CBCT scannings of the specimens were carried out using the same protocol and settings as mentioned earlier.

Evaluation of the pre- and postinstrumentation cone beam computed tomographic scans

The parameters measured were mesiodistal canal transportation, buccolingual transportation, centering ratio, and percent increase in the prepared outline. Canal transportation was measured using formula (a1-a2)-(b1-b2), proposed by Gambill *et al*.[10] The measurement from the mesial wall of the uninstrumented root canal to the outer wall of the root is a1, the measurement from distal wall of the uninstrumented root canal to the outer wall of the root is b2, the measurement from mesial wall of the instrumented root canal to the outer wall of the root is a2, and the measurement from distal wall of the instrumented root canal to the outer wall of the root is b2. Buccolingual transportation was measured by the formula (c1-c2)-(d1-d2). The shortest measurement from the buccal margin of the root to the buccal margin of the uninstrumented root canal is c1, the shortest measurement from the buccal margin of the root to the buccal margin of the instrumented canal is c2, the shortest measurement from the lingual margin of the root to the lingual margin of the uninstrumented canal is d1, and the shortest

measurement from the lingual margin of the root to the lingual margin of the instrumented canal is d2. A result of 0 would indicate no canal transportation. The ability of the instrument to remain centered in the canal is defined as the mean centering ratio. It was calculated using the following formula: (a1-a2)/(b1-b2) or (b1-b2)/(a1-a2). A result of 1 indicates good centering ability of the file.

Statistical analysis

The Kruskal–Wallis nonparametric test compared differences in the amount of dentin removed, canal transportation, and canal-centering ability between the three file systems for three independent groups. Statistics were considered significant at a $P = 0.05$.

RESULTS

Each group's pre- and postoperative CBCT measurements differed significantly ($P < 0.05$), according to the nonparametric test. TRN group showed the least amount of dentin removed at all levels [Table 1]. At 5 mm level, XPS showed higher mean mesiodistal canal transportation (0.12 ± 0.15) as compared to TRN and HCM files [Table 2]. Pre- and postinstrumentation images of CBCT scans at level 5 mm from the apex are shown in Figure 1. There was no statistically significant difference in relation to canal-centering ability [Table 3].

DISCUSSION

The primary risk factor for the failure of instruments is canal curvature. Mesiobuccal canals are more prone to excess dentin removal, followed by fracture due to their smaller mesiodistal diameter. Curved mesiobuccal root canals also have a higher risk of canal transportation than other canals.[11] Hence, in this study, mesiobuccal root canals of mandibular molars were selected to evaluate the canal transportation and the amount of dentin removed.

Imaging techniques like CBCT, Computed tomography, and Micro Computed Tomography have shown superiority over standard radiographs when assessing shaping ability of endodontic instruments. CBCT is an effective noninvasive imaging technique. Larger voxel sizes allow for more accurate detection of fine anatomical details.[12]

The superelasticity of NiTi alloy makes the rotary files more effective for cleaning and shaping of root canals. Green[13] investigated the role of instrument taper on dentin conservation and discovered that instruments with 0.06 taper removed more dentin than instruments with a 0.04 taper. Hence, this study used instruments with 0.04 taper.

The current study showed a significant difference between the three file systems when assessing the amount of dentin removed. TRN showed significantly better dentin preservation when compared to XPS and HCM files. The special heat treatment, reduced flute diameter of 0.8 mm, and offset parallelogram cross-section of TRN rotary files might have contributed to more conservative preparation, observed in this study.

Falakaloğlu *et al*.[14] reported that TRN, VDW.ROTATE, and ProTaper Gold systems showed similar shaping ability in printed resin-based mandibular mesial roots without

Table 1: Amount of dentin removed

Levels (mm)	Groups	Mean±SD	Median	95% CI	Kruskal–Wallis test	*P*
3	XPS	0.167±0.433	0.0800	(−0.202)–0.199	7.88	0.019*
	TRN	0.0433±0.0307	0.0600	0.0292–0.0575		
	HCM	0.0478±0.0418	0.0450	0.0285–0.0671		
5	XPS	0.111±0.0714	0.0850	0.0781–0.144	6.63	0.036*
	TRN	0.0528±0.0361	0.0700	0.0361–0.0695		
	HCM	0.0861±0.118	0.0700	0.0318–0.140		
8	XPS	0.148±0.138	0.115	0.0845–0.212	8.35	0.015*
	TRN	0.0500±0.0415	0.0700	0.0303–0.0697		
	HCM	0.0733±0.0447	0.0700	0.0527–0.0940		

*Statistical significance ($P<0.05$), SD: Standard deviation, CI: Confidence interval, XPS: XP-endo Shaper, TRN: TruNatomy, HCM: HyFlex CM, CI: Confidence interval

Table 2: B-L and M-D canal transportation

Levels (mm)	Groups	Mean±SD	Kruskal–Wallis test	*P*	Levels (mm)	Groups	Mean±SD	Kruskal–Wallis test	*P*
3	XPS	−0.0278±0.331	1.02	0.601	3	XPS	0.0950±0.147	4.19	0.123
	TRN	−0.0411±0.272				TRN	0.0933±0.0543		
	HCM	0.0717±0.262				HCM	0.0667±0.0754		
5	XPS	−0.0289±0.296	1.29	0.525	5	XPS	0.126±0.150	8.25	0.016*
	TRN	−0.162±0.253				TRN	0.0644±0.0988		
	HCM	−0.183±0.410				HCM	0.0389±0.0361		
8	XPS	−0.168±0.553	5.60	0.061	8	XPS	0.154±0.207	1.67	0.435
	TRN	−0.287±0.461				TRN	0.127±0.114		
	HCM	−0.0128±0.243				HCM	0.124±0.163		

*Statistical significance ($P<0.05$), SD: Standard deviation, XPS: XP-endo Shaper, TRN: TruNatomy, HCM: HyFlex CM

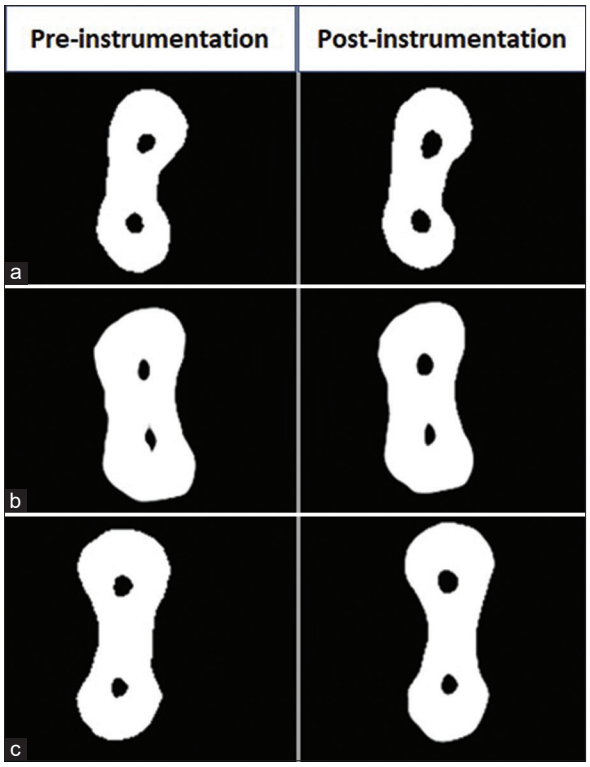

Figure 1: Axial slices of canals, before and after preparation with (a) XP-endo Shaper, (b) TruNatomy and, (c) HyFlex CM 5 mm from apex

Table 3: Canal-centering ability of the three file systems

Levels (mm)	Groups	Mean±SD	Median	95% CI	Kruskal–Wallis test	*P*
3	XPS	2.10±2.01	1.69	1.17–3.03	1.91	0.385
	TRN	1.22±1.38	1.45	0.584–1.86		
	HCM	1.82±1.72	1.32	1.02–2.61		
5	XPS	5.15±7.52	2.01	1.68–8.62	5.77	0.056
	TRN	3.31±2.12	2.65	2.33–4.29		
	HCM	1.73±1.50	1.57	1.03–2.42		
8	XPS	2.24±2.91	1.55	0.890–3.58	2.10	0.349
	TRN	3.79±5.41	1.85	1.30–6.29		
	HCM	2.21±2.60	1.29	1.01–3.41		

SD: Standard deviation, CI: Confidence interval, XPS: XP-endo Shaper, TRN: TruNatomy, HCM: HyFlex CM

clinically significant error, however, TRN touched the highest percentage of root canal surface.

During the instrumentation of curved canals, it is important to preserve the inner canal curvature and maintain the original canal anatomy in the apical area. Severe transportation of the canal may thin the root canal walls, resulting in perforations or vertical fractures.[15] In a study conducted by Shaheen and Elhelbawy[16] Wave one gold showed significantly more transportation of the canal at the coronal and mid-third levels as compared to XPS and TRN. However, Versiani *et al*.[17] found that XPS drastically affected the configuration of the root canal when compared to iRaCe and EdgeFile systems. Kapasi *et al*.[18] reported that XPS + XPendo Finisher R files showed promising results in the preservation of root dentin.

XPS is a unique instrument made from MaxWire technology. The instrument benefits from its one-of-a-kind alloy type in a variety of ways. XPS moves in a snake-like manner. XPS can expand in root canals from 0.01 to 0.04 taper according to the manufacturer. This may help it to adapt to the root canal anatomy.[19] In a study by Arıcan Öztürk *et al*.,[6] it was found that XPS removed more dentin compared to the ProTaper Next system. This indicates that XPS expands more than 0.04 taper, which could explain why it showed higher mesiodistal canal transportation than TRN and HCM files at 5 mm level.

In this study, HCM showed less canal transportation and was similar to TRN files. A special NiTi alloy that has lower weight percent of nickel (52%) is used for the manufacture of HCM instruments. These instruments are subjected to thermomechanical process which imparts superior flexibility.[20] The HCM files controlled memory effect aids in the file's ability to retain the canal's shape.[21] The findings of the present study are in accordance with study done by Siang Lin *et al*.[22] who suggested that TFlex, HCM, and Vortex Blue showed better shaping ability, while TFlex and HCM preserved the original canal curvatures better. Kishore *et al*.[23] reported that canal preparation with the HCM file system showed lesser transportation and better centering ability than twisted files and wave one file system.

The centering ratio measures the ability of the instruments to remain centered in the canal. The lower the ratio, the better the instrument will perform.[24] All three file systems showed a similar canal-centering ability. However, Werdina and Bahnam[25] showed that XPS had a relatively low centering ability than Edge Evolve and HCM.

As clinical conditions differ, additional *in vivo* studies may be undertaken to substantiate these findings. Further research can be undertaken using more NiTi rotary files to check the effectiveness of these emerging systems in cleaning and shaping root canals.

CONCLUSIONS

Within the scope of the study, we can conclude that the TRN file system performed better in terms of dentin preservation than the XPS and HCM. At 5 mm, the XPS demonstrated the greatest canal transportation (mid-root level). In terms of centering ability, all three rotary file systems performed similarly.

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Conflicts of interest
There are no conflicts of interest.

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